WHAT IS CLAIMED IS:

1. A method for inducing or enhancing the threshold voltage of an electrophoretic display, which method comprises adding a threshold promoter into an electrophoretic fluid which comprises charged pigment particles or pigment-containing microparticles dispersed in a dielectric solvent or solvent mixture, wherein said threshold promoter is represented by one of the following formulas:

$$R—[Q—L—(X)_m]_q \qquad (T\text{-}1)$$

$$R—[Q—L—X—Q'—(L'—Y)_m]_q \qquad (T\text{-}2)$$

$$R—[Q—L—(X—Q'—L'—Y)_m]_q \qquad (T\text{-}3)$$

$$[(X)_m—L—Q]_q—R—[Q'—L'—(Y)_{m'}]_{q'} \qquad (T\text{-}4)$$

wherein:

m and m' are independently natural numbers which are ≥1;

q and q' are independently natural numbers which are ≥1;

R is a halogenated group or a halogenated polymeric or oligomeric chain;

Q and L or Q' and L' together forming a linking chain; and

X and Y are independently functional groups capable of forming hydrogen bonding, acid-base interaction, donor-acceptor interaction, metal-ligand interaction or Coulombic interaction.

2. The method of Claim 1 wherein Q in -Q-L or Q' in -Q'-L'- is independently absent, ether (-O -), thioether (-S -), amide (-CON<, -CONR^{12}- or -R^{12}NCO-), imide [(-CO)$_2$N-], urea (-R^{12}NCONR^{13}-), thiourea (-R^{12}NCSNR^{13}-), urethane (-OCONR^{12}- or –R^{12}NCOO-), thiourethane (-OCSNR^{12}- or -R^{12}NCSO-), ester (-COO- or –OOC-), carbonate [-OC(O)O-], imine (=N-) or amine (-NR^{12}-) wherein R^{12} and R^{13} are independently hydrogen, alkyl, aryl, alkylaryl, polyether and derivatives thereof.

3. The method of Claim 1 wherein m and m' are independently 1 or 2.

4. The method of Claim 1 wherein q and q' are independently 1 or 2.

5. The method of Claim 1 wherein X and Y are independently

–OH, -SH, $-NH_2$, -NH-, =N-, $>N^+<$, $=N^+<$, -CO-, -COO-, -OCO-, $-COO^-$, -COOH, -COOCO-, -O-, $-CONR^8-$, $-CONH_2$, $-OCONR^8-$, $-NR^8COR^9$, $-R^8NCONR^9-$, $-CONR^8CO-$, -OCOO-, -SO-, $-SO_2-$, $-SO_2^-$, $-SO_3^-$, $-SO_4^-$, $-SO_2H$, $-SO_3H$, $-PO_4H_2$, $-PO_4^{-2}$, $-PO_4H^-$, $-PO_3H_2$, $-PO_3H^-$, $-SO_2NH-$, $-SO_2NR^8-$, pyridinium or quaternary ammonium salt, metal or metal ions or chelated derivatives thereof (in which R^8 and R^9 are independently hydrogen, alkyl or fluorinated alkyl of 1 to 30 carbon atoms).

6. The method of Claim 5 wherein X or Y is a pyridinium salt formed with a counterion selected from a group consisting of F^-, Cl^-, Br^-, I^-, NO_3^-, NO_2^-, $CO_3^=$, $SO_3^=$, $SO_4^=$, $PO_3^=$, PO_4^{3-}, MnO_4^-, $Cr_2O_7^=$, $CrO_3^=$, BF_4^-, PF_6^-, AsF_6^- or SbF_6^-; optionally fluorinated aliphatic carboxylates or sulfonates; anions of optionally fluorinated sulfonyl imides; anions of optionally fluorinated aromatic carboxylates or sulfonates and fluoropolyether substituted carboxylates or sulfonates.

7. The method of Claim 6 wherein said optionally fluorinated aliphatic sulfonate is $C_aH_bF_{(2a+1-b)}SO_3^-$ wherein a is 1-30 and b is 0-61.

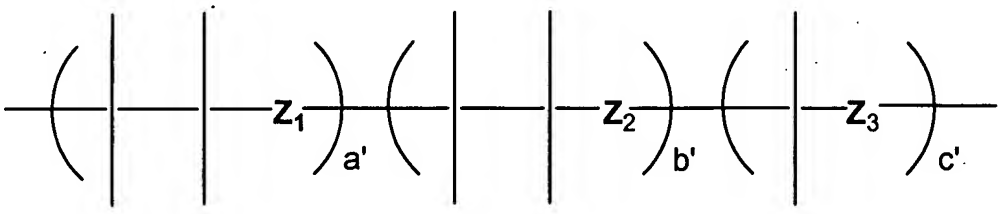
8. The method of Claim 6 wherein said optionally fluorinated aliphatic carboxylates is $C_aH_bF_{(2a+1-b)}CO_2^-$ wherein a is 1-30 and b is 0-61.

9. The method of Claim 6 wherein said counterion is $F(C_3F_6O)_dCF(CF_3)CO_2^-$, $F(C_3F_6O)_dCF_2CF_2CO_2^-$, $CF_3O(C_2F_4O)_dCF_2CO_2^-$, $F(C_2F_4O)_dCF_2CO_2^-$, $F(C_3F_6O)_dCF(CF_3)SO_3^-$, $F(C_3F_6O)_dCF_2CF_2SO_3^-$, $CF_3O(C_2F_4O)_dCF_2SO_3^-$ or $F(C_2F_4O)_dCF_2SO_3^-$ wherein d is 1-20.

10. The method of Claim 5 wherein said pyridinium salt is formed with an anion of Krytox® acid.

11. The method of Claim 1 wherein R is fluorinated alkyl or fluorinated aryl.

12. The method of Claim 1 wherein R is a polymeric or oligomeric chain represented by the following formula:



(R)

wherein the open substituent positions (not designated) on the main chain are independently selected from a group consisting of hydrogen, halogen (especially fluoro), alkyl, alkenyl, aryl, alkylaryl, fluoroalkyl, fluoroalkenyl, fluoroaryl, fluoroalkylaryl, $-OR^{10}$, $OCOR^{10}$, $-COOR^{10}$, $-CONR^{10}R^{11}$ (wherein R^{10} and R^{11} are independently hydrogen, alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl or fluorinated polyether) and substituted derivatives thereof;

Z_1, Z_2, and Z_3 are independently oxygen or absent; and

a', b' and c' are the weight fractions of the corresponding repeating units and are independently in the range of 0-1 with their sum no greater than 1.

13. The method of Claim 12 wherein the open substituent positions are fluorine or fluorinated alkyl.

14. The method of Claim 1 wherein said threshold promoter is represented by Formula T-1:

wherein

m is 1 or 2;

q is 1 or 2;

Q is absent, an amide, urea or urethane moiety;

L is a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms; and

X is hydroxyl, amino or $-NR^8COR^9$ wherein R^8 and R^9 are independently hydrogen, alkyl or fluorinated alkyl.

15. The method of Claim 14 wherein R is a fluorinated alkyl.

16. The method of Claim 14 wherein R is a fluoropolyether.

17. The method of Claim 14 wherein R is a polymeric or oligomeric chain of Formula (R).

18. The method of Claim 17 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

19. The method of Claim 14 wherein m is 2, q is 1, L is a straight or branched alkylene or alkylphenylene chain optionally interrupted by one or more nitrogen atoms.

20. The method of Claim 19 wherein L is a straight or branched alkylene chain optionally interrupted by one or more nitrogen atoms.

21. The method of Claim 1 wherein said threshold promoter is represented by Formula T-2:

wherein

Q and Q' are independently absent, an amide, urea or urethane moiety;

L and L' are independently a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain, optionally interrupted by one or more heteroatoms;

X is a pyridinium ion;

Y is –OH or amino;

m and m' are independently 1 or 2; and

q is 1 or 2.

22. The method of Claim 21 wherein R is a fluorinated alkyl.

23. The method of Claim 21 wherein R is a fluoropolyether.

24. The method of Claim 21 wherein R is a polymeric or oligomeric chain of Formula (R).

25. The method of Claim 24 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

26. The method of Claim 21 wherein L and L' are independently a straight or branched alkylene chain optionally interrupted by one or more nitrogen atoms.

27. The method of Claim 21 wherein Y is –OH.

28. The method of Claim 1 wherein said threshold promoter is a pyiridium salt.

29. The method of Claim 28 wherein said pyridinium salt has a counterion selected from a group consisting of $C_aF_{2a+1}SO_3^-$, $F(C_3F_6O)_dCF(CF_3)CO_2$- and $F(C_2F_4O)_dCF_2CO_2$- in which a is 1-12 and d is 1-20.

30. An electrophoretic fluid comprising charged pigment particles or pigment-containing microparticles dispersed in a dielectric solvent or solvent mixture and a threshold promoter of the following formula:

$R—[Q—L—(X)_m]_q$ (T-1)

$R—[Q—L—X—Q'—(L'—Y)_m]_q$ (T-2)

$$R—[Q—L—(X—Q'—L'—Y)_m]_q \qquad (T\text{-}3)$$

$$[(X)_m—L—Q]_q—R—[Q'—L'—(Y)_{m'}]_{q'} \qquad (T\text{-}4)$$

wherein:

m and m' are independently natural numbers which are ≥1;

q and q' are independently natural numbers which are ≥1;

R is a halogenated group or a halogenated polymeric or oligomeric chain;

Q and L or Q' and L' together forming a linking chain; and

X and Y are independently functional groups capable of forming hydrogen bonding, acid-base interaction, donor-acceptor interaction, metal-ligand interaction or Coulombic interaction.

31. The electrophoretic fluid Claim 30 wherein said threshold promoter is represented by Formula T-1:

wherein

m is 1 or 2;

q is 1 or 2;

Q is absent, an amide, urea or urethane moiety;

L is a straight or branched alkylene, alkylphenylene, fluorinated alkylene, or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms; and

X is hydroxyl, amino or $–NR^8COR^9$ wherein R^8 and R^9 are independently hydrogen, alkyl or fluorinated alkyl.

32. The method of Claim 31 wherein R is a fluorinated alkyl.

33. The method of Claim 31 wherein R is a fluoropolyether.

34. The method of Claim 31 wherein R is a polymeric or oligomeric chain of Formula (R).

35. The method of Claim 34 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

36. The electrophoretic fluid of Claim 31 wherein m is 2, q is 1, L is a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more nitrogen atoms.

37. The method of Claim 36 wherein L is a straight or branched alkylene chain optionally interrupted by one or more nitrogen atoms.

38. The electrophoretic fluid of Claim 30 wherein said threshold promoter is represented by Formula T-2:

wherein

Q and Q' are independently absent, an amide, urea or urethane moiety;

L and L' are independently a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms;

X is a pyridinium ion;

Y is –OH or amino;

m and m' are independently 1 or 2; and

q is 1 or 2.

39. The method of Claim 38 wherein R is a fluorinated alkyl.

40. The method of Claim 38 wherein R is a fluoropolyether.

41. The method of Claim 38 wherein R is a polymeric or oligomeric chain of Formula (R).

42. The method of Claim 41 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

43. The method of Claim 38 wherein Y is –OH.

44. The electrophoretic fluid of Claim 38 wherein said pyiridium ion is reacted with a counterion selected from a group consisting of $C_aF_{2a+1}SO_3^-$, $F(C_3F_6O)_dCF(CF_3)CO_2^-$ and $F(C_2F_4O)_dCF_2CO_2^-$ in which a is 1-12 and d is 1-20.

45. The electrophoretic fluid of Claim 30 wherein the threshold promoter is present in the amount of from about 0.1% by weight to about 20% by weight based upon the total amount of pigment particles.

46. The electrophoretic fluid of Claim 45 wherein the threshold promoter is present in the amount of from about 0.2% by weight to about 5% by weight based upon the total amount of pigment particles.

47. The electrophoretic fluid of Claim 30 wherein said pigment particles are white pigment particles.

48. The electrophoretic fluid of Claim 30 wherein said dielectric solvent is a halogenated solvent.

49. The electrophoretic fluid of Claim 48 wherein said dielectric solvent is a fluorinated solvent.

50. The electrophoretic fluid of Claim 49 wherein said dielectric solvent is a perfluorinated solvent.

51. The electrophoretic fluid of Claim 30 wherein said threshold promoter is adsorbed or chemically bonded on the surface of the particles.

52. The electrophoretic fluid of Claim 30 wherein said threshold promoter is adsorbed or chemically bonded on the surface of an electrode conductor.

53. The electrophoretic fluid of Claim 30 wherein said threshold promoter is adsorbed or chemically bonded on the surface of an electrode protection layer.

54. The electrophoretic display of Claim 30 wherein said dielectric solvent or solvent mixture is colored by a Si phthalocyanine or naphthalocyanine dye, a Cu phthalocyanine or naphthalocyanine dye or a mixture thereof.

55. An electrophoretic display comprising display cells filled with an electrophoretic fluid comprising charged pigment particles or pigment-containing microparticles dispersed in a dielectric solvent or solvent mixture and a threshold voltage promoter of the formula:

$$R—[Q—L—(X)_m]_q \qquad (T\text{-}1)$$

$$R—[Q—L—X—Q'—(L'—Y)_m]_q \qquad (T\text{-}2)$$

$$R—[Q—L—(X—Q'—L'—Y)_m]_q \qquad (T\text{-}3)$$

$$[(X)_m—L—Q]_q—R—[Q'—L'—(Y)_{m'}]_{q'} \qquad (T\text{-}4)$$

wherein:

m and m' are independently natural numbers which are ≥1;

q and q' are independently natural numbers which are ≥1;

R is a halogenated group or a halogenated polymeric or oligomeric chain;

Q and L or Q' and L' together forming a linking chain; and

X and Y are independently functional groups capable of forming hydrogen bonding, acid-base interaction, donor-acceptor interaction, metal-ligand interaction or Coulombic interaction.

56. The display of Claim 55 wherein said threshold promoter is represented by Formula T-1:

wherein

m is 1 or 2;

q is 1 or 2;

Q is absent, an amide, urea or urethane moiety;

L is a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms; and

X is hydroxy, amino or $-NR^8COR^9$ wherein R^8 and R^9 are independently hydrogen, alkyl or fluorinated alkyl.

57. The method of Claim 56 wherein R is a fluorinated alkyl.

58. The method of Claim 56 wherein R is a fluoropolyether.

59. The method of Claim 56 wherein R is a polymeric or oligomeric chain of Formula (R).

60. The method of Claim 59 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

61. The display of Claim 56 wherein m is 2, q is 1, L is a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more nitrogen atoms.

62. The display of Claim 61 wherein L is a straight or branched alkylene chain optionally interrupted by one or more nitrogen atoms.

63. The display of Claim 55 wherein said threshold promoter is represented by Formula T-2:

wherein

Q and Q' are independently absent, an amide, urea or urethane moiety;

L and L' are independently a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms;

X is a pyridinium ion;

Y is –OH or amino;

m and m' are independently 1 or 2; and

q is 1 or 2.

64. The method of Claim 63 wherein R is a fluorinated alkyl.

65. The method of Claim 63 wherein R is a fluoropolyether.

66. The method of Claim 63 wherein R is a polymeric or oligomeric chain of Formula (R).

67. The method of Claim 66 wherein the open substituent positions on the main chain of Formula (R) are fluorine or fluorinated alkyl.

68. The method of Claim 63 wherein Y is –OH.

69. The display of Claim 63 wherein said pyiridium ion is reacted with a counterion selected from a group consisting of $C_aF_{2a+1}SO_3^-$, $F(C_3F_6O)_dCF(CF_3)CO_2^-$ and $F(C_2F_4O)_dCF_2CO_2^-$ in which a is 1-12 and d is 1-20.

70. The electrophoretic display of Claim 55 which is prepared by the microcup technology.

71. The electrophoretic display of Claim 55 which is prepared by the microencapsulation process.

72. The method of Claim 1 wherein said threshold promoter is represented by Formula T-4:

wherein

R is a fluoropolyether;

Q and Q' are independently absent, amide, urea or urethane;

L and L' are independently a straight or branched alkylene, alkylphenylene, fluorinated alkylene or fluorinated alkylphenylene chain optionally interrupted by one or more heteroatoms;

X and Y are independently hydroxyl or amino;

m is 1 or 2; and

q is 1 or 2.

73. The method of Claim 72 wherein X and Y are independently hydroxyl.

74. The method of Claim 73 wherein L and L' are independently an alkylene chain optionally interrupted by one or more nitrogen atoms, m, m', q and q' are all 1.